

§ 434.403

10 CFR Ch. II (1–13 Edition)

TABLE 402.4.2—EQUIP DEFAULT VALUES FOR ENVSTD24

Occupancy	Default equipment power density ¹	Default occupant load adjustment ¹	Default adjusted equipment power density
Assembly	0.25	0.75	1.00
Health/Institutional	1.00	–0.26	0.74
Hotel/Motel	0.25	–0.33	0.00
Warehouse/Storage	0.10	–0.60	0.00
Multi-Family High Rise	0.75	N/A	0.00
Office	0.75	–0.35	0.40
Restaurant	0.10	0.07	0.17
Retail	0.25	–0.38	0.00
School	0.50	0.30	0.80

¹ Defaults as defined in Section 8.6.10.5, Table 8–4, and Sections 8.6.10.6 and 13.7.2.1, Table 13–2 from RS–1 (incorporated by reference, see § 434.701).

402.4.2.1 Equipment Power Density (EQUIP). The equipment power density used in the ENVSTD24 computer program shall use the actual equipment power density from the building plans and specifications or be taken from Table 402.4.2 using the column titled “Default Adjusted Equipment Power Density” or calculated for the building using the procedures of RS–1. (incorporated by reference, see § 434.701). The program limits consideration of the equipment power density to a maximum of 1 W/ft².

402.4.2.2 Lighting Power Density (LIGHTS). The lighting power density used in the ENVSTD24 computer program shall use the actual lighting power density from the building plans

and specifications or the appropriate value from Tables 401.3.2a, b, c, or d.

402.4.2.3 Daylighting Control Credit Fraction (DLCF). When the daylighting control credit fraction is other than zero, automatic daylighting controls shall be installed in the appropriate perimeter zones(s) of the building to justify the credit.

§ 434.403 Building mechanical systems and equipment.

Mechanical systems and equipment used to provide heating, ventilating, and air conditioning functions as well as additional functions not related to space conditioning, such as, but not limited to, freeze protection in fire projection systems and water heating, shall meet the requirements of this section.

403.1 Mechanical Equipment Efficiency. When equipment shown in Tables 403.1a through 403.1f is used, it shall have a minimum performance at the specified rating conditions when tested in accordance with the specified reference standard. The reference standards listed in Tables 403.1a through 403.1f are incorporated by reference, see § 434.701. Omission of minimum performance requirements for equipment not listed in Tables 403.1a through 403.1f does not preclude use of such equipment.

TABLE 403.1A—UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum Efficiency ²	Test procedure ¹
Air Conditioners, Air Cooled.	< 65,000 Btu/h	Split system	10.0 SEER	ARI 210/240 (RS–15)*
		Single Package	9.7 SEER	
		Split System and Single Package ..	8.9 EER ³	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package ..	8.3 IPLV ³	ARI 210/240 (RS–15)*
		Split System and Single Package ..	8.5 EER ³	
		Split System and Single Package ..	7.5 IPLV ³	
Air Conditioners, Water and Evaporatively Cooled.	< 65,000 Btu/h	Split System and Single Package ..	8.5 EER ³	ARI–340/360 (RS–16)*
		Split System and Single Package ..	7.5 IPLV ³	
		Split System and Package	8.3 EER ³	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package ..	7.5 IPLV ³	ARI–340/360 (RS–16)*
		Split System and Single Package ..	9.3 EER ³	
		Split System and Single Package ..	8.4 IPLV ³	
Condensing Units, Air Cooled.	< 65,000 Btu/h	Split System and Single Package ..	10.5 EER ^c	ARI 210/240 (RS–15)*
		Split System and Single Package ..	9.7 IPLV ^c	
		Split System and Single Package ..	9.6 EER ^c	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package ..	9.0 IPLV ^c	ARI–340/360 (RS–16)*
		Split System and Single Package ..	9.6 EER ^c	
		Split System and Single Package ..	9.0 IPLV ^c	
Condensing Units, Air Cooled.	135,000 Btu/h	9.9 EER	ARI 365 (RS–29)*
		.....	11.0 IPLV

Department of Energy

§ 434.403

TABLE 403.1A—UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS—Continued

Equipment type	Size category	Subcategory or rating condition	Minimum Efficiency ²	Test procedure ¹
Condensing Units, Water or Evaporatively Cooled.	135,000 Btu/h .....	.....	12.9 EER	ARI 365 (RS-29)*

¹ See subpart E for detailed references.

² IPLVs are only applicable to equipment with capacity modulation.

³ Deduct 0.2 from the required EERs and IPLVs for units that have a heating section.

* Incorporation by reference, see § 434.701.

TABLE 403.1B—UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency ²	Test procedure ¹
Air Cooled (Cooling Mode).	<65,000 Btu/h	Split System	10.0 SEER	ARI 210/240 (RS-15)*
		Single Package	9.7 SEER	
	≥65,000 Btu/h and <135,000 Btu/h.	Split System and Single Package.	8.9 EER ³	ARI 210/240 (RS-15)*
	≥135,000 Btu/h and <240,000 Btu/h.	Split System and Single Package.	8.3 IPLV ³	
	≥240,000 Btu/h	Split System and Single Package.	8.5 EER ³	ARI-340/360 (RS-16)*
Water Source	<65,000 Btu/h	Split System and Single Package.	7.5 IPLV ³	ARI-340/360 (RS-16)*
		85 °F Entering Water	9.3 EER	ARI-320 (RS-27)*
		75 °F Entering Water	10.2 EER	
	≥65,000 Btu/h and <135,000 Btu/h	85 °F Entering Water	10.5 EER	ARI-320 (RS-27)*
	<135,000 Btu/h	75 °F Entering Water	11.0 EER	ARI 325 (RS-28)*
Groundwater-Source (Cooling Mode).		70 F Entering Water	11.5 EER	
Ground Source (Cooling Mode).	<135,000 Btu/h	50 F Entering Water		
		77 F Entering Water	10.0 EER	ARI 325 (RS-28)*
		70 F Entering Water	10.4 EER	
	<65,000 Btu/h (Cooling Capacity).	Split System	6.8 HSPF	ARI 210/240 (RS-15)*
	65,000 Btu/h and <135,000 Btu/h (Cooling Capacity).	Single Package	6.6 HSPF	
Air Cooled (Heating Mode).	135,000 Btu/h (Cooling Capacity).	47 F db/43 F wb Outdoor Air	3.00 COP	ARI 210/240 (RS-15)*
		17 F db/15 F wb Outdoor Air	2.00 COP	ARI-340/360 (RS-1/)*
	135,000 Btu/h (Cooling Capacity).	47 F db/43 F wb Outdoor Air	2.90 COP	
	<135,000 Btu/h (Cooling Capacity).	17 F db/15 F wb Outdoor	2.00 COP	ARI-320 (RS-27)*
	<135,000 Btu/h (Cooling Capacity).	70 F Entering Water	3.80 COP	
Water-Source (Heating Mode).		75 F Entering Water	3.90 COP	ARI 325 (RS-28)*
Groundwater-Source (Heating Mode).	<135,000 Btu/h (Cooling Capacity).	70 F Entering Water	3.40 COP	
		50 F Entering Water	3.00 COP	
	<135,000 Btu/h (Cooling Capacity).	32 F Entering Water	2.50 EER	ARI-330 (RS-45)*
		41 F Entering Water	2.70 EER	

¹ See subpart E for detailed references.

² IPLVs are only applicable to equipment with capacity modulation.

³ Deduct 0.2 from the required EERs and IPLVs for units that have a heating section.

* Incorporation by reference, see § 434.701.

TABLE 403.1C—WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency ²	Test procedure ¹
Air-Cooled, With Condenser, Electrically Operated.	<150 Tons	2.70 COP	2.50 COP	ARI 550 Centrifugal/ Rotary Screw (RS-30)* or ARI 590 Reciprocating (RS-31)*
	≥150 Tons	2.80 IPLV	2.50 IPLV	
Air-Cooled, Without Condenser, Electrically Operated.	All Capacities .....	.....	3.10 COP
			3.20 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating).	All Capacities	3.80 COP	
			3.90 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll).	<150 Tons		3.80 COP	
	≥150 Tons and <300 Tons.		3.90 IPLV	
	≥300 Tons		4.20 COP	
			4.50 IPLV	
			5.20 COP	
			5.30 IPLV	

TABLE 403.1C—WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS—Continued

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency ²	Test procedure ¹
Water-Cooled, Electrically Operated, Centrifugal.	<150 Tons 150 Tons and <300 Tons 300 Tons	3.80 COP	ARI 550 (RS–30)*
			3.90 IPLV	
			4.20 COP	
			4.50 IPLV	
			5.20 COP	
Absorption Single Effect	All Capacities	5.30 IPLV	ARI 560 (RS–46)*
Absorption Double Effect, Indirect-Fired.	All Capacities .....	.....	0.48 COP
Absorption Double-Effect, Direct-Fired.	All Capacities .....	.....	0.95 COP
			1.00 IPLV	
	All Capacities	0.95 COP	
			1.00 IPLV	

¹ See subpart E for detailed references.² Equipment must comply with all efficiencies when multiple efficiencies are indicated.

*Incorporation by reference, see § 434.701.

TABLE 403.1D—PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, ROOM AIR CONDITIONERS, AND ROOM AIR-CONDITIONER HEAT PUMPS ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency ²	Test procedure ¹
PTAC (Cooling Mode)	All Capacities	95 °F db Outdoor Air	10.0–(0.16 × Cap/1,000) ³ EER.	ARI 310/380 (RS–17)*
		82 °F db Outdoor Air	12.2–(0.20 × Cap/1,000) ³ EER.	
PTHP (Cooling Mode)	All Capacities	95 °F db Outdoor Air	10.0–(0.16 × Cap/1,000) ³ EER.	ARI 310/380 (RS–17)*
		82 °F db Outdoor Air	12.2–(0.20 × Cap/1,000) EER.	
PTHP (Heating Mode)	All Capacities	2.90–(0.026 × CAP/1,000) ³ COP.	ANSI/AHAM RAC–1 (RS–40)*
Room Air Conditioners, With Louvered Sides.	<6,000 Btu/h ≥6,000 Btu/h and <8,000 Btu/h ≥8,000 Btu/h and <14,000 Btu/h ≥14,000 Btu/h and <20,000 Btu/h ≥20,000 Btu/h .....	.....	8.0 EER
			8.5 EER	
			9.0 EER	
			8.8 EER	
			8.2 EER	
Room Air Conditioner, Without Louvered Sides.	<6,000 Btu/h ≥6,000 Btu/h and <20,000 Btu/h ≥20,000 Btu/h	8.0 EER	ANSI/AHAM RAC–1 (RS–40)*
			8.5 EER	
			8.2 EER	
Room Air-Conditioner Heat Pumps With Louvered Sides.	All Capacities	8.5 EER	ANSI/AHAM RAC–1 (RS–40)*
Room Air-Conditioner Heat Pumps Without Louvered Sides.	All Capacities .....	.....	8.0 EER

¹ See subpart E for detailed references.² Equipment must comply with all efficiencies when multiple efficiencies are indicated. (Note products covered by the 1992 Energy Policy Act have no efficiency requirement for operation at other than standard rating conditions for products manufactured after 1/1/94).³ Cap means the rated capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

*Incorporation by reference, see § 434.701.

TABLE 403.1E—WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency ^{b,c}	Test procedure ^a
Warm Air-Furnace, Gas-Fired	< 225,000 Btu/h ....	.....	78% AFUE or 80% E _t	DOE 10 CFR 430 Appendix N ANSI Z21.47 (RS–21)*
	≥ 225,000 Btu/h	Maximum Capacity ^c	80% E _t	
Warm Air-Furnace, Oil-Fired ..	< 225,000 Btu/h	Minimum Capacity ^c	78% E _t	DOE 10 CFR 430 Appendix N
		.....	78% AFUE or 80% E _t ^d	

Department of Energy

§ 434.403

TABLE 403.1E—WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS—Continued

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency ^{b,c}	Test procedure ^a
Warm Air Duct Furnaces, Gas-Fired.	≥ 225,000 Btu/h	Maximum Capacity ^c	81% E _t	U.L. 727
		Minimum Capacity	81% E _t	(RS-22)*
	All Capacities	Maximum Capacity ^c	78% E _t	ANSI Z83.9
		Minimum Capacity	75% E _t	(RS-23)
Warm Air Unit Heaters, Gas Fired.	All Capacities	Maximum Capacity ^c	78% E _t	ANSI Z83.8
		Minimum Capacity	74% E _t	(RS-24)*
Oil-Fired	All Capacities	Maximum Capacity ^c	81% E _t	U.L. 731
		Minimum Capacity	81% E _t	(RS-25)*

^a See subpart E for detailed references.

^b Minimum and maximum ratings as provided for and allowed by the unit's controls.

^c Combination units not covered by NAECA (Three-phase power or cooling capacity ≥ 65,000 Btu/h) may comply with either rating.

^d E_t = thermal efficiency. See referenced document for detailed discussion.

^e E_c = combustion efficiency. Units must also include an IID and either power venting or a flue damper. For those furnaces where combustion air is drawn from the conditioned space, a vent damper may be substituted for a flue damper.

* Incorporation by reference, see § 434.701

TABLE 403.1F—BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment type	Size category	Subcategory or rating condition	Minimum efficiency ^b	Test procedure ^a
Boilers, Gas-Fired	<300,000 Btu/h	Hot Water	80% AGUE	DOE 10 CFR 430 Appendix N
		Steam	75% AGUE	DOE 10 CFR 430 Appendix N
	<300,000 Btu/h	Maximum Capacity ^c	80% E _c	ANSI Z21.13
		Minimum Capacity	80% E _c	(RS-32)*
Boilers, Oil-Fired	<300,000 Btu/h		80% AGUE	DOE 10 CFR 430 (RS-20)*
	<300,000 Btu/h	Maximum Capacity ^c	83% E _c	U.L. 726
Oil-Fired (Residual)	<3000,000 Btu/h	Minimum Capacity	83% E _c	(RS-33)*
		Maximum Capacity ^c	83% E _c	
		Minimum Capacity	83% E _c	

^a See subpart E for detailed references.

^b Minimum and maximum ratings as provided for and allowed by the unit's controls.

^c E_c = combustion efficiency (100% less flue losses). See reference document for detailed information.

* Incorporation by reference, see § 434.701.

403.1.1 Where multiple rating conditions and/or performance requirements are provided, the equipment shall satisfy all stated requirements.

403.1.2 Equipment used to provide water heating functions as part of a combination integrated system shall satisfy all stated requirements for the appropriate space heating or cooling category.

403.1.3 The equipment efficiency shall be supported by data furnished by the manufacturer or shall be certified under a nationally recognized certification program or rating procedure.

403.1.4 Where components, such as indoor or outdoor coils, from different manufacturers are used, the system designer shall specify component efficiencies whose combined efficiency meets the standards herein.

403.2 HVAC Systems.

403.2.1 *Load Calculations.* Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with the procedures described in RS-1 (incorporated by reference, see § 434.701) using the design parameters specified in subpart C of this part.

403.2.2 *Equipment and System Sizing.* Heating and cooling equipment and systems shall be sized to provide no more than the loads calculated in accordance with subsection 403.2.1. A single piece of equipment providing both heating and cooling must satisfy this provision for one function with the other function sized as small as possible to meet the load, within available equipment options. Exceptions are as follows:

(a) When the equipment selected is the smallest size needed to meet the load within available options of the desired equipment line.

(b) Standby equipment provided with controls and devices that allow such equipment to operate automatically only when the primary equipment is not operating.

(c) Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that sequence or otherwise optimally control the operation of each unit based on load.

403.2.3 *Separate Air Distribution System.* Zones with special process temperature and/or humidity requirements shall be served by air distribution systems separate from those serving zones requiring only comfort conditions or shall include supplementary provisions so that the primary systems may be specifically controlled for comfort purposes only. Exceptions: Zones requiring only comfort heating or comfort cooling that are served by a system primarily used for process temperature and humidity control need not be served by a separate system if the total supply air to these comfort zones is no more than 25% of the total system supply air or the total conditioned floor area of the zones is less than 1000 ft².

403.2.4 *Ventilation and Fan System Design.* Ventilation systems shall be designed to be capable of reducing the supply of outdoor air to the minimum ventilation rates required by Section 6.1.3 of RS-41 (incorporated by reference, see § 434.701) through the use of return ducts, manually or automatically operated control dampers, fan volume controls, or other devices. Exceptions are as follows: Minimum outdoor air rates may be greater if:

(a) Required to make up air exhausted for source control of contaminants such as in a fume hood.

(b) Required by process systems.

(c) Required to maintain a slightly positive building pressure. For this purpose, minimum outside air intake may be increased up to no greater than 0.30 air changes per hour in excess of exhaust quantities.

403.2.4.1 *Ventilation controls for variable or high occupancy areas.* Systems with design outside air capacities

greater than 3,000 cfm serving areas having an average design occupancy density exceeding 100 people per 1,000 ft² shall include means to automatically reduce outside air intake to the minimum values required by RS-41 (incorporated by reference, see § 434.701) during unoccupied or low-occupancy periods. Outside air shall not be reduced below 0.14 cfm/ft². Outside air intake shall be controlled by one or more of the following:

(a) A clearly labeled, readily accessible bypass timer that may be used by occupants or operating personnel to temporarily increase minimum outside air flow up to design levels.

(b) A carbon dioxide (CO₂) control system having sensors located in the spaces served, or in the return air from the spaces served, capable of maintaining space CO₂ concentrations below levels recommended by the manufacturer, but no fewer than one sensor per 25,000 ft² of occupied space shall be provided.

(c) An automatic timeclock that can be programmed to maintain minimum outside air intake levels commensurate with scheduled occupancy levels.

(d) Spaces equipped with occupancy sensors.

403.2.4.2 *Ventilation Controls for enclosed parking garages.* Garage ventilation fan systems with a total design capacity greater than 30,000 cfm shall have automatic controls that stage fans or modulate fan volume as required to maintain carbon monoxide (CO) below levels recommended in RS-41.

403.2.4.3 *Ventilation and Fan Power.* The fan system energy demand of each HVAC system at design conditions shall not exceed 0.8 W/cfm of supply air for constant air volume systems and 1.25 W/cfm of supply air for variable-air-volume (VAV) systems. Fan system energy demand shall not include the additional power required by air treatment or filtering systems with pressure drops over 1 in. w.c. Individual VAV fans with motors 75 hp and larger shall include controls and devices necessary for the fan motor to demand no more than 30 percent of design wattage at 50 percent of design air volume, based on manufacturer's test data. Exceptions are as follows:

(a) Systems with total fan system motor horsepower of 10 hp or less.

(b) Unitary equipment for which the energy used by the fan is considered in the efficiency ratings of subsection 403.1.

403.2.5 *Pumping System Design.* HVAC pumping systems used for comfort heating and/or comfort air conditioning that serve control valves designed to modulate or step open and closed as a function of load shall be designed for variable fluid flow and capable of reducing system flow to 50 percent of design flow or less. Exceptions are as follows:

(a) Systems where a minimum flow greater than 50% of the design flow is required for the proper operation of equipment served by the system, such as chillers.

(b) Systems that serve no more than one control valve.

(c) Systems with a total pump system horse power ≤ 10 hp.

(d) Systems that comply with subsection 403.2.6.8 without exception.

403.2.6 *Temperature and Humidity Controls.*

403.2.6.1 *System Controls.* Each heating and cooling system shall include at least one temperature control device.

403.2.6.2 *Zone Controls.* The supply of heating and cooling energy to each zone shall be controlled by individual thermostatic controls responding to temperature within the zone. For the purposes of this section, a dwelling unit is considered a zone. Exceptions are as follows: Independent perimeter systems that are designed to offset building envelope heat losses or gains or both may serve one or more zones also served by an interior system when the perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation for at least 50 contiguous ft and the perimeter system heating and cooling supply is controlled by thermostat(s) located within the zone(s) served by the system.

403.2.6.3 *Zone Thermostatic Control Capabilities.* Where used to control comfort heating, zone thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors down to 55 °F or lower. Where used to control comfort

cooling, zone thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors up to 85 °F or higher. Where used to control both comfort heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or deadband of at least 5 °F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Exceptions are as follows:

(a) Special occupancy or special usage conditions approved by the building official or

(b) Thermostats that require manual changeover between heating and cooling modes.

403.2.6.4 *Heat Pump Auxiliary Heat.* Heat pumps having supplementary electric resistance heaters shall have controls that prevent heater operation when the heating load can be met by the heat pump. Supplemental heater operation is permitted during outdoor coil defrost cycles not exceeding 15 minutes.

403.2.6.5 *Humidistats.* Humidistats used for comfort purposes shall be capable of being set to prevent the use of fossil fuel or electricity to reduce relative humidity below 60% or increase relative humidity above 30%.

403.2.6.6 *Simultaneous Heating and Cooling.* Zone thermostatic and humidistatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the zone. Such controls shall prevent: Reheating; recooling; mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by mechanical refrigeration or by economizer systems; and other simultaneous operation of heating and cooling systems to the same zone. Exceptions are as follows:

(a) Variable-air-volume systems that, during periods of occupancy, are designed to reduce the air supply to each zone to a minimum before heating, recooling, or mixing takes place. This minimum volume shall be no greater than the larger of 30% of the peak supply volume, the minimum required to meet minimum ventilation requirements of the Federal agency. (0.4 cfm/

ft² of zone conditioned floor area, and 300 cfm).

(b) Zones where special pressurization relationships or cross-contamination requirements are such that variable-air-volume systems are impractical, such as isolation rooms, operating areas of hospitals and clean rooms.

(c) At least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.

(d) Zones where specified humidity levels are required to satisfy process needs, such as computer rooms and museums.

(e) Zones with a peak supply air quantity of 300 cfm or less.

403.2.6.7 Temperature Reset for Air Systems. Air systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply air temperatures by representative building loads or by outside air temperature. Temperature shall be reset by at least 25% of the design supply air to room air temperature difference. Zones that are expected to experience relatively constant loads, such as interior zones, shall be designed for the fully reset supply temperature. Exception are as follows: Systems that comply with subsection 403.2.6.6 without using exceptions (a) or (b).

403.2.6.8 Temperature Reset for Hydronic Systems. Hydronic systems of at least 600,000 Btu/hr design capacity supplying heated and/or chilled water to comfort conditioning systems shall include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature. Temperature shall be reset by at least 25% of the design supply-to-return water temperature difference. Exceptions are as follows:

(a) Systems that comply with subsection 403.2.5 without exception or

(b) Where the design engineer certifies to the building official that supply temperature reset controls cannot be implemented without causing improper operation of heating, cooling, humidification, or dehumidification systems.

403.2.7 Off Hour Controls.

403.2.7.1 Automatic Setback or Shutdown Controls. HVAC systems shall be equipped with automatic controls capable of accomplishing a reduction of energy use through control setback or equipment shutdown. Exceptions are as follows:

(a) Systems serving areas expected to operate continuously or

(b) Equipment with full load demands not exceeding 2 kW controlled by readily accessible, manual off-hour controls.

403.2.7.2 Shutoff Dampers. Outdoor air supply and exhaust systems shall be provided with motorized or gravity dampers or other means of automatic volume shutoff or reduction. Exceptions are as follows:

(a) Systems serving areas expected to operate continuously.

(b) Individual systems which have a design airflow rate or 3000 cfm or less.

(c) Gravity and other non-electrical ventilation systems controlled by readily accessible, manual damper controls.

(d) Where restricted by health and life safety codes.

403.2.7.3 Zone Isolation systems that serve zones that can be expected to operate nonsimultaneously for more than 750 hours per year shall include isolation devices and controls to shut off or set back the supply of heating and cooling to each zone independently. Isolation is not required for zones expected to operate continuously or expected to be inoperative only when all other zones are inoperative. For buildings where occupancy patterns are not known at the time of system design, such as speculative buildings, the designer may predesignate isolation areas. The grouping of zones on one floor into a single isolation area shall be permitted when the total conditioned floor area does not exceed 25,000 ft² per group.

403.2.8 Economizer Controls.

403.2.8.1 Each fan system shall be designed and capable of being controlled to take advantage of favorable weather conditions to reduce mechanical cooling requirements. The system shall include either: A temperature or enthalpy air economizer system that is capable of automatically modulating outside air and return air dampers to

Department of Energy

§ 434.403

provide up to 85% of the design supply air quantity as outside air, or a water economizer system that is capable of cooling supply air by direct and/or indirect evaporation and is capable of providing 100% of the expected system cooling load at outside air temperatures of 50 °F dry-bulb/45 °F wet-bulb and below. Exceptions are as follows:

(a) Individual fan-cooling units with a supply capacity of less than 3000 cfm or a total cooling capacity less than 90,000 Btu/h.

(b) Systems with air-cooled or evaporatively cooled condensers that include extensive filtering equipment provided in order to meet the requirements of RS-41 (incorporated by reference, see § 434.701).

(c) Systems with air-cooled or evaporatively cooled condensers where the design engineer certifies to the building official that use of outdoor air cooling affects the operation of other systems, such as humidification, dehumidification, and supermarket refrigeration systems, so as to increase overall energy usage.

(d) Systems that serve envelope-dominated spaces whose sensible cooling load at design conditions, excluding transmission and infiltration loads, is less than or equal to transmission and infiltration losses at an outdoor temperature of 60 °F.

(e) Systems serving residential spaces and hotel or motel rooms.

(f) Systems for which at least 75% of the annual energy used for mechanical cooling is provided from a site-recovered or site-solar energy source.

(g) The zone(s) served by the system each have operable openings (windows, doors, etc.) with an openable area greater than 5% of the conditioned floor area. This applies only to spaces open to and within 20 ft of the operable

openings. Automatic controls shall be provided that lock out system mechanical cooling to these zones when outdoor air temperatures are less than 60 °F.

403.2.8.2 Economizer systems shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load. Exceptions are as follows:

(a) Direct-expansion systems may include controls to reduce the quantity of outdoor air as required to prevent coil frosting at the lowest step of compressor unloading. Individual direct-expansion units that have a cooling capacity of 180,000 Btu/h or less may use economizer controls that preclude economizer operation whenever mechanical cooling is required simultaneously.

(b) Systems in climates with less than 750 average operating hours per year between 8 a.m. and 4 p.m. when the ambient dry-bulb temperatures are between 55 °F and 69 °F inclusive.

403.2.8.3 System design and economizer controls shall be such that economizer operation does not increase the building heating energy use during normal operation.

403.2.9 *Distribution System Construction and Insulation.*

403.2.9.1 *Piping Insulation.* All HVAC system piping shall be thermally insulated in accordance with Table 403.2.9.1. Exceptions are as follows:

(a) Factory-installed piping within HVAC equipment tested and rated in accordance with subsection 403.1.

(b) Piping that conveys fluids that have a design operating temperature range between 55 °F and 105 °F.

(c) Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electricity.

TABLE 403.2.9.1—MINIMUM PIPE INSULATION (IN.)^A

Fluid Design Operating Temp. Range (F)	Insulation conductivity ^a		Nominal pipe diameter (in.)				
	Conductivity Range Btu in./ (h ft ² F)	Mean Temp. F	<1.0	1.0 to 1.25	1.5 to 3.0	4.0 to 6.0	8.0
Heating systems (Steam, Steam Condensate, and Hot Water)^{b,c}							
>350	0.32–0.34	250	1.0	1.5	1.5	2.0	2.5
251–350	0.29–0.32	200	1.0	1.0	1.5	2.0	2.0
201–250	0.27–0.30	150	1.0	1.0	1.0	1.5	1.5
141–200	0.25–0.29	125	1.0	1.0	1.0	1.5	1.5

TABLE 403.2.9.1—MINIMUM PIPE INSULATION (IN.)^A—Continued

Fluid Design Operating Temp. Range (F)	Insulation conductivity ^a		Nominal pipe diameter (in.)				
	Conductivity Range Btu in./ (h ft ² F)	Mean Temp. F	<1.0	1.0 to 1.25	1.5 to 3.0	4.0 to 6.0	8.0
105–140	0.22–0.28	100	0.5	0.5	0.75	1.0	1.0
Domestic and Service Hot Water Systems							
105 and Greater	0.22–0.28	100	0.5	0.5	0.75	1.0	1.0
Cooling Systems (Chilled Water, Brine, and Refrigerant)^d							
40–55	0.22–0.28	100	0.5	0.5	0.5	0.5	0.5
Below 40	0.22–0.28	100	0.5	0.5	0.5	0.5	0.5

^aFor insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r(1 + \frac{t}{r})^{K/k} - 1$

Where T = minimum insulation thickness (in), r = actual outside radius of pipe (in), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu in/h ft² F); and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

^bThese thicknesses are based on energy efficiency considerations only. Safety issues, such as insulation surface temperatures, have not been considered.

^cPiping insulation is not required between the control valve and coil on run-outs when the control valve is located within four feet of the coil and the pipe diameter is 1 inch or less.

^dNote that the required minimum thickness does not take water vapor transmission and possible surface condensation into account.

TABLE 403.2.9.2—MINIMUM DUCT INSULATION R-VALUE^A

Duct location	Cooling supply ducts				Heating supply ducts				Return ducts
	CDD65 ≤500	500< CDD65 ≤1,000	1,000< CDD65 ≤2,000	CDD65 ≥2,000	HDD65 ≤1,500	1,500< HDD65 ≤4,500	4,500< HDD65 ≤7,500	HDD65 ≥7,500	
Exterior of Building	R-3.3 ...	R-5.0 ...	R-6.5 ...	R-8.0 ...	R-3.3 ...	R-5.0 ...	R-6.5 ...	R-8.0 ...	R-5.0
Ventilated Attic	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-3.3
Unvented Attic	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-3.3
Other Conditioned Spaces ^b	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3
Indirectly Conditioned Spaces ^c	none	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	R-3.3 ...	none
Buried	none	none	none	none	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-5.0 ...	R-3.3

^aInsulation R-values, measured in (h.ft².°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thickness do not consider water vapor transmission and possible surface condensation. The required minimum thicknesses do not consider water vapor transmission and condensation. For ducts that are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of this section or subsection 402. Insulation resistance measured on a horizontal plane in accordance with RS-6 (incorporated by reference, see § 434.701) at a mean temperature of 75 °F. RS-6 is incorporated by reference at § 434.701.

^bIncludes crawl spaces, both ventilated and non-ventilated.

^cIncludes return air plenums, with and without exposed roofs above.

403.2.9.2 Duct and Plenum Insulation. All supply and return air ducts and plenums installed as part of an HVAC air distribution system shall be thermally insulated in accordance with Table 403.2.9.1. Exceptions are as follows:

(a) Factory-installed plenums, casings, or ductwork furnished as a part of the HVAC equipment tested and rated in accordance with subsection 403.1

(b) Ducts within the conditioned space that they serve. (incorporated by reference, see § 434.701)ca a06oc0.186

403.2.9.3 Duct and Plenum Construction. All air-handling ductwork and plenums shall be constructed and erected in accordance with RS-34, RS-35, and RS-36 (incorporated by reference, see § 434.701). Where supply ductwork and plenums designed to operate at static pressures from 0.25 in. wc to 2 in. wc, inclusive, are located outside of the conditioned space or in return plenums, joints shall be sealed in accordance with Seal Class C as defined in RS-34 (incorporated by reference, see § 434.701). Pressure sensitive tape shall not be used as the primary

sealant where such ducts are designed to operate at static pressures of 1 in. wc, or greater.

403.2.9.3.1 Ductwork designed to operate at static pressures in excess of 3 in. wc shall be leak-tested in accordance with Section 5 of RS-35, (incorporated by reference, see § 434.701), or equivalent. Test reports shall be provided in accordance with Section 6 of RS-35, (incorporated by reference, see § 434.701)m or equivalent. The tested duct leakage class at a test pressure equal to the design duct pressure class rating shall be equal to or less than leakage Class 6 as defined in Section 4.1 of RS-35 (incorporated by reference, see § 434.701). Representative sections totaling at least 25% of the total installed duct area for the designated pressure class shall be tested.

403.2.10 *Completion.*

403.2.10.1 *Manuals.* Construction documents shall require an operating and maintenance manual provided to the Federal Agency. The manual shall include, at a minimum, the following:

(a) Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance, including assumptions used in outdoor design calculations.

(b) Operating and maintenance manuals for each piece of equipment requiring maintenance. Required maintenance activity shall be specified.

(c) Names and addresses of at least one qualified service agency to perform the required periodic maintenance shall be provided.

(d) HVAC controls systems maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field determined setpoints shall be permanently recorded on control drawings, at control devices, or, for digital control systems, in programming comments.

(e) A complete narrative, prepared by the designer, of how each system is intended to operate shall be included with the construction documents.

403.2.10.2 *Drawings.* Construction documents shall require that within 30 days after the date of system acceptance, record drawings of the actual installation be provided to the Federal agency. The drawings shall include de-

tails of the air barrier installation in every envelope component, demonstrating continuity of the air barrier at all joints and penetrations.

403.2.10.3 *Air System Balancing.* Construction documents shall require that all HVAC systems be balanced in accordance with the industry accepted procedures (such as National Environmental Balancing Bureau (NEBB) Procedural Standards, Associated Air Balance Council (AABC) National Standards, or ANSI/ASHRAE Standard 111). Air and water flow rates shall be measured and adjusted to deliver final flow rates within 10% of design rates, except variable flow distribution systems need not be balanced upstream of the controlling device (VAV box or control valve).

403.2.10.3.1 Construction documents shall require a written balance report be provided to the Federal agency for HVAC systems serving zones with a total conditioned area exceeding 5,000 ft².

403.2.10.3.2 Air systems shall be balanced in a manner to first minimize throttling losses, then fan speed shall be adjusted to meet design flow conditions or equivalent procedures. Exceptions are as follows: Damper throttling may be used for air system balancing;

(a) With fan motors of 1 hp (0.746 kW) or less, or

(b) Of throttling results in no greater than 1/3 hp (0.248 kW) fan horsepower draw above that required if the fan speed were adjusted.

403.2.10.4 *Hydronic System Balancing.* Hydronic systems shall be balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Exceptions are as follows:

(a) Pumps with pump motors of 10 hp (7.46 kW) or less.

(b) If throttling results in no greater than 3 hp (2.23 kW) pump horsepower draw above that required if the impeller were trimmed.

(c) To reserve additional pump pressure capability in open circuit piping systems subject to fouling. Valve throttling pressure drop shall not exceed that expected for future fouling.

403.2.10.5 *Control System Testing.* HVAC control systems shall be tested

§ 434.404

10 CFR Ch. II (1–13 Edition)

to assure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft² conditioned area, detailed instructions for commissioning HVAC systems shall be provided by the designer in plans and specifications.

§ 434.404 Building service systems and equipment.

404.1 *Service Water Heating Equipment Efficiency.* Equipment must satisfy the minimum performance efficiency specified in Table 404.1 when tested in accordance with RS-37, RS-38, or RS-39 (incorporated by reference, see § 434.701). Omission of equipment from Table 404.1 shall not preclude the use of

such equipment. Service water heating equipment used to provide additional function of space heating as part of a combination (integrated) system shall satisfy all stated requirements for the service water heating equipment. All gas-fired storage water heaters that are not equipped with a flue damper and use indoor air for combustion or draft hood dilution and that are installed in a conditioned space, shall be equipped with a vent damper listed in accordance with RS-42 (incorporated by reference, see § 434.701). Unless the water heater has an available electrical supply, the installation of such a vent damper shall not require an electrical connection.

TABLE 404.1—MINIMUM PERFORMANCE OF WATER HEATING EQUIPMENT

Category	Type	Fuel	Input rating	V _T	Input to V _T ratio Btuh/gal	Test Method ^a	Energy factor	Thermal efficiency E _t %	Standby loss %/HR
NAECA	all	electric	12 kW	all ^c		DOE Test	0.93–0.00132V		
Covered	storage	gas	75,000 Btuh	all ^c		Procedure 10	0.62–0.0019V		
Water	instantaneous	gas	200,000	all		CFR part 430	0.62–0.0019V		
Heating	storage	oil	Btuh ^c	all		430	0.59–0.0019V		
Equipment ^b	instantaneous	oil	105,000 Btuh	all		Appendix E	0.59–0.0019V		
	pool heater ...	gas/oil	210,000 Btuh	all		ANSI Z21.56 (RS-38)*		78	
Other Water Heating	storage	electric	all	all		ANSI Z21.10.3		78	.030+27/V _T
Equipment ^d	storage/	gas/oil	155m999 Btuh	all	<4,000	(RS-39)*		78	1.3+114//V _T
	instantaneous		>155,000 Btuh	all <10	<4,000			80	1.3+95/V _T
				10	4,000			77	2.3+67/V _T
Unfired					all				6.5 Btuh/ft ²
Storage									
Tanks									

^aFor detailed references see subpart E.

^bConsistent with National Appliance Energy Conservation Act (NAECA) of 1987.

^cDOE Test Procedures apply to electric and gas storage water heaters with rated volumes 20 gallons and gas instantaneous water heaters with input ratings of 50,000 to 200,000 Btuh.

^dAll except those water heaters covered by NAECA.

*Incorporated by reference, see § 434.701.

404.1.1 Testing Electric and Oil Storage Water Heaters for Standby Loss.

(a) When testing an electric storage water heater, the procedures of Z21.10.3–1990 (RS-39, incorporated by reference, see § 434.701), Section 2.9, shall be used. The electrical supply voltage shall be maintained with ±1%

of the center of the voltage range specified on the water heater nameplate. Also, when needed for calculations, the thermal efficiency (E_t) shall be 98%. When testing an oil-fired water heater, the procedures of Z21.10.3–1990 (RS-39, incorporated by reference, see § 434.701), Sections 2.8 and 2.9, shall be used.